



Designation: **A501/A501M—14 A501/A501M – 21**

Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing¹

This standard is issued under the fixed designation A501/A501M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This specification covers black and hot-dipped galvanized hot-formed welded and seamless carbon steel square, round, rectangular, or special shape structural tubing for welded, riveted, or bolted construction of bridges and buildings, and for general structural purposes.

1.2 Square and rectangular tubing is furnished in sizes produced with flats of 1 to 3216 in. [25 to 800 mm] across flat sides with wall thicknesses 0.095 to 3.00405 mm and a specified wall thickness 0.095 to 1.0 in. [2.5 to 75 mm], dependent upon size; round tubing is furnished in NPS 25 mm]. Round tubing is produced $\frac{1}{2}$ [DN 15] to NPS 24 [DN 600] (see **Note 1**) inclusive, with nominal (average) wall thicknesses 0.109 to 1.000 in. [2.8 to 25.4 mm], dependent upon size. Special shape tubing and tubing with other dimensions is permitted to be furnished, provided that such tubing complies with all other requirements of this specification with diameters of 1 to 48 in. [25 to 1220 mm] and a specified wall thickness of 0.095 to 4.00 in. [2.5 to 100 mm].

Note 1—The dimensionless designator NPS [DN] (nominal pipe size) has been substituted in this standard for such traditional terms as “nominal diameter,” “size,” and “nominal size.”

1.3 This specification covers the following grades: three grades: A, B, and C.

<https://standards.iteh.ai/catalog/standards/sist/cea22057-9752-466c-ba7f-2b40a1b5775a/astm-a501-a501m-21>

1.3.1 Grade A — 36 000 psi [250 MPa] min yield strength.

1.3.2 Grade B — 50 000 psi [345 MPa] min yield strength.

1.4 An optional supplementary requirement is provided for Grade B and, when desired, shall be so stated on the order. The text of this specification contains notes and footnotes that provide explanatory material. Such notes and footnotes, excluding those in tables and figures, do not contain any mandatory requirements.

1.5 The following precautionary statement pertains only to the test method portion of this specification: *This standard does not purport to address all the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 This specification is expressed in both inch-pound units and in SI units; however, unless the purchase order specifies the applicable M specification designation (SI units), the inch-pound units shall apply. The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated

¹ This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.09 on Carbon Steel Tubular Products.

Current edition approved Oct. 1, 2014/Aug. 1, 2021. Published October 2014/September 2021. Originally approved in 1964. Last previous edition approved in 2007/2014 as A501—07/A501/A501M—14. DOI: 10.1520/A0501_A0501M-14.10.1520/A0501_A0501M-21.

*A Summary of Changes section appears at the end of this standard

in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

~~1.7 The text of this specification contains notes and footnotes that provide explanatory material. Such notes and footnotes, excluding those in tables and figures, do not contain any mandatory requirements.~~

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

[A53/A53M Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless](#)

[A370 Test Methods and Definitions for Mechanical Testing of Steel Products](#)

[A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment](#)

[A751 Test Methods and Practices for Chemical Analysis of Steel Products](#)

[A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys](#)

2.2 AIAG Standard:³

[B-1 Bar Code Symbology Standard](#)

2.3 Federal Standard:⁴

[Fed. Std. No. 123 Marking for Shipments \(Civil Agencies\)](#)

2.4 Military Standards:⁴

[MIL-STD-129 Marking for Shipment and Storage](#)

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminology [A941](#).

4. Ordering Information

4.1 Orders for material under this specification shall contain information concerning as many of the following items as are required to describe the desired material adequately:

4.1.1 ~~Quantity (feet [metres] (weight in metric tons, feet [meters], or number of lengths),~~

4.1.2 Name of material (hot-formed tubing),

~~4.1.3 Grade (A or B)~~

4.1.3 Method of manufacture (seamless or welded) (~~seewelded~~); see Section [6](#));²

4.1.4 ~~Finish (black or galvanized), Grade (A, B, or C),~~

4.1.5 Size (outside diameter and ~~calculated nominal wall thickness for round tubing and the outside dimensions and calculated nominal wall thickness for square and rectangular tubing (Section [tubing](#), [H](#))~~);

4.1.6 Finish (black or galvanized),

4.1.7 Length (random, multiple, or specific; see ~~12.3~~[12.4](#)),

4.1.8 End condition (see ~~17.3~~[17.5](#)),

4.1.9 Burr removal (see ~~17.3~~[17.5](#)),

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from Automotive Industry Action Group (AIAG), 26200 Lahser Rd., Suite 200, Southfield, MI 48033, <http://www.aiag.org>.

⁴ Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, <http://www.access.gpo.gov>.

4.1.10 Certification (see Section 19),

4.1.11 ASTM specification designation and year of issue,

~~4.1.12 End use,~~

~~4.1.13 Special requirements, and~~

4.1.12 Bar coding (see 20.3),

4.1.13 Packaging, package marking, and loading for shipment (see Section 21),

4.1.14 Product analysis (see Supplementary Requirements S2),

4.1.15 End use, and

4.1.16 Special requirements.

5. Process

5.1 The steel shall be made by ~~any commercially acceptable~~ basic-oxygen or electric-arc-furnace steel making process.

5.2 Steel may be cast in ingots or may be strand cast.

5.3 When steels of different grades are sequentially strand cast, the steel producer shall identify the resultant transition material and remove it using an established procedure that positively separates the grades.

6. Manufacture

6.1 The tubing shall be made by one of the following processes: seamless; ~~furnace-butt welding~~ furnace-butt-welding (continuous welding); electric-resistance welding or submerged arc welding followed by reheating throughout the cross section and hot forming by a reducing or shaping process, or both.

6.2 The final shape formation shall be made by a hot forming process.

6.3 The weld shall not be located within the radius of the corners of any tube having one or more flat sides.

6.4 It shall be permissible to add a normalizing heat treatment for tubing with a wall thickness greater than 1/2 in. [13 mm].

7. Heat Analysis

7.1 Each heat analysis shall conform to the requirements specified in **Table 1** ~~for heat analysis.~~

8. Product Analysis

8.1 ~~The~~ When product analysis is ordered (see 4.1.14 and S2) the tubing shall be capable of conforming to the requirements specified in **Table 1** for product analysis.

8.2 ~~If product analyses are made, they shall be made using test specimens taken from two lengths of tubing from each lot of 500 lengths, or fraction thereof, or two pieces of flat-rolled stock from each lot of a corresponding quantity of flat-rolled stock. Methods and practices relating to chemical analysis shall be in accordance with Test Methods, Practices, and Terminology **A751**. Such product analyses shall conform to the requirements specified in **Table 1** for product analysis.~~

8.3 ~~If both product analyses representing a lot fail to conform to the specified requirements, the lot shall be rejected.~~

TABLE 1 Chemical Requirements^A

Element	Composition, %			
	Grade A		Grade BB, C	
	Heat analysis	Product analysis	Heat analysis	Product analysis
Carbon, max	0.26	0.30	0.22 ^B	0.26
Carbon, max ^B	0.26	0.30	0.22	0.26
Manganese, max	1.40 ^B	1.45
Manganese, max ^B	1.40	1.45
Phosphorus, max	0.035	0.045	0.030	0.040
Sulfur, max	0.035	0.045	0.020	0.030
Copper, when copper steel is specified, min	0.20	0.18	0.20	0.18

^AWhere an ellipsis (...) appears in this table, there is no requirement.

^BFor each reduction of 0.01 percentage point below the specified maximum for carbon, an increase of 0.06 percentage point above the specified maximum for manganese is permitted, up to a maximum of 1.60% by heat analysis and 1.65% by product analysis.

8.4 If only one product analysis representing a lot fails to conform to the specified requirements, product analyses shall be made using two additional test specimens taken from the lot. Both additional product analyses shall conform to the specified requirements or the lot shall be rejected.

9. Tensile Requirements

9.1 The material, as represented by the test specimen, shall conform to the requirements as to tensile properties—tensile property requirements prescribed in Table 2.

9.2 The yield strength corresponding to a permanent offset of 0.2% of the gauge length of the specimen or to a total extension of 0.5% of the gauge length under load shall be determined. Elongation may be determined on a gauge length of either 2 in. or 8 in. [50 mm or 200 mm] at the manufacturer's choice.

10. Charpy V-Notch Impact Test Requirements

10.1 The Charpy V-notch impact test specimens shall conform to requirements prescribed in Table 2. Impact tests are not required for thicknesses smaller than or equal to 0.250 in. [6.3 mm], unless specified.

10.2 The Charpy V-notch impact Charpy V-notch tests shall be made in accordance with Test Methods and Definitions A370 test applies to Grade B only and wall thickness greater than 0.312 in. [8 mm]. One test shall consist of a set of three specimens. Standard specimens 10 by 10 mm [0.394 by 0.394 in.] in cross section shall be used unless the material to be tested is of insufficient thickness, in which case the largest obtainable subsize specimens shall be used. Acceptance criteria for subsize specimens shall be in accordance with Test Methods and Definitions A370.

10.1.1 Charpy V-notch tests shall be made in accordance with Test Methods and Definitions A370

10.1.2 One Charpy V-notch impact test shall be made from a length of tubing representing each lot.

10.1.3 The test results of full-size longitudinal specimens shall meet an average value of 20 ft-lb at 0 °F [-18 °C].

10.3 One Charpy V-notch impact test shall be made from a length of tubing representing each lot.

10.4 The test results of standard full-size longitudinal specimens shall meet a minimum average per set of three specimens and minimum single value as specified in Table 2. The specimen axis shall be parallel to the tubing axis and the notch shall be normal to the surface of the material. For wall thicknesses 1.5 in. [38 mm] and less, the specimens shall be located with their surface at least 0.08 in. [2 mm] from the material surface; for wall thicknesses greater than 1.5 in. [38 mm], the specimens shall be located with their surface at least 1/4 times the wall thickness from the material surface.

10.5 The maximum test temperature shall be 0 °F [-18 °C].



TABLE 2 Tensile Requirements

	Grade A	Grade B	
Tensile strength, min, psi [MPa]	58 000 [400] 36 000 [250]	70 000 [483] 50 000 [345]	
Yield strength, min, psi [MPa]	Elongation in 2 in. [50 mm], min, %		23

TABLE 2 Tensile and Impact Requirements

	Wall Thickness, in. [mm]	Grade A	Grade B	Grade C
Tensile strength, min, psi [MPa]	All	58 000 [400]	65 000 [448]	70 000 [483]
	≤ 1 [25]	39 000 [270]	46 000 [315]	50 000 [345]
Yield strength, min, psi [MPa]	> 1 [25] and ≤ 2 [50]	38 000 [260]	45 000 [310]	49 000 [340]
	> 2 [50] and ≤ 3 [76]	36 500 [250]	42 500 [290]	47 500 [330]
Elongation, min, %	> 3 [76] and ≤ 4 [100]	35 000 [240]	40 000 [280]	46 000 [315]
		25	24	23
Impact Energy, min. average ft/lbf [J] (see 10.4)		20 [27]	20 [27]	20 [27]
min. single ft/lbf [J] (see 10.4)		14 [19]	14 [19]	14 [19]

TABLE 3 Dimensions of Common Sizes of Square Structural Tubing

Size Given in Outside Dimensions Across Flat Sides, in. [mm]	Weight per Unit Length, lb/ft [kg/m]	Calculated Nominal Wall Thickness, in. [mm]
1-by-1 [25-by-25]	1.09 — [1.6]	0.095 — [2.4]
	1.41 — [2.1]	0.133 — [3.4]
2-by-2 [50-by-50]	2.69 — [4.00]	0.110 — [2.8]
	3.04 — [4.5]	0.125 — [3.2]
	3.65 — [5.4]	0.154 — [4.0]
	4.31 — [6.41]	0.188 — [4.8]
2½-by-2½ [65-by-65]	4.32 — [6.4]	0.141 — [3.6]
	5.59 — [8.3]	0.188 — [4.8]
	7.10 — [10.6]	0.250 — [6.4]
3-by-3 [75-by-75]	5.78 — [8.6]	0.156 — [4.0]
	6.86 — [10.2]	0.188 — [4.8]
	8.80 — [13.1]	0.250 — [6.4]
3½-by-3½ [90-by-90]	6.88 — [10.2]	0.156 — [4.0]
	8.14 — [12.1]	0.188 — [4.8]
	10.50 — [15.6]	0.250 — [6.4]
	12.69 — [18.9]	0.312 — [7.9]
4-by-4 [100-by-100]	9.31 — [13.9]	0.188 — [4.8]
	12.02 — [17.9]	0.250 — [6.4]
	14.52 — [21.6]	0.312 — [7.9]
	16.84 — [25.1]	0.375 — [9.5]
	20.88 — [31.1]	0.500 — [12.7]
5-by-5 [130-by-130]	11.86 — [17.7]	0.188 — [4.8]
	15.42 — [22.9]	0.250 — [6.4]
	18.77 — [27.9]	0.312 — [7.9]
	21.94 — [32.7]	0.375 — [9.5]
	27.68 — [41.2]	0.500 — [12.7]
6-by-6 [150-by-150]	14.41 — [21.4]	0.188 — [4.8]
	18.82 — [28.0]	0.250 — [6.4]
	23.02 — [34.3]	0.312 — [7.9]
	27.04 — [40.3]	0.375 — [9.5]
	34.48 — [51.3]	0.500 — [12.7]
7-by-7 [175-by-175]	16.85 — [25.1]	0.188 — [4.8]
	22.04 — [32.8]	0.250 — [6.4]
	26.99 — [39.2]	0.312 — [7.9]
	31.73 — [47.2]	0.375 — [9.5]
	40.55 — [60.3]	0.500 — [12.7]
8-by-8 [200-by-200]	25.44 — [37.9]	0.250 — [6.4]
	31.24 — [46.5]	0.312 — [7.9]



TABLE 3—Continued

Size Given in Outside Dimensions Across Flat Sides, in. [mm]	Weight per Unit Length, lb/ft [kg/m]		Calculated Nominal Wall Thickness, in. [mm]	
	36.83	—[54.8]	0.375	—[9.5]
	47.35	—[70.5]	0.500	—[12.7]
	56.98	—[84.9]	0.625	—[15.9]
				[16.0]
	65.73	—[97.8]	0.750	—[19.1]
10 by 10 [250 by 250]	32.23	—[48.0]	0.250	—[6.4]
	39.74	—[59.1]	0.312	—[7.9]
	47.03	—[70.0]	0.375	—[9.5]
	60.95	—[90.7]	0.500	—[12.7]
	73.98	—[110.1]	0.625	—[15.9]
	86.13	—[128.2]	0.750	—[19.1]
	107.79	—[160.4]	1.000	—[25.4]
12 by 12 [300 by 300]	76.39	—[113.7]	0.50	—[12.7]
	94.51	—[140.6]	0.63	—[16.0]
	110.61	—[164.6]	0.75	—[19.1]
14 by 14 [355 by 355]	90.01	—[133.9]	0.50	—[12.7]
	111.66	—[166.1]	0.63	—[16.0]
	131.04	—[195.0]	0.75	—[19.1]
	140.49	—[209.0]	0.81	—[20.6]
	145.40	—[216.4]	0.87	—[22.0]
	162.18	—[241.3]	0.98	—[25.0]
16 by 16 [405 by 405]	103.62	—[154.2]	0.50	—[12.7]
	128.81	—[191.7]	0.63	—[16.0]
	162.52	—[241.8]	0.81	—[20.6]
	168.99	—[251.4]	0.87	—[22.0]
	188.98	—[281.2]	0.98	—[25.0]
	208.24	—[309.8]	1.10	—[28.0]
18 by 18 [460 by 460]	267.09	—[397.4]	1.26	—[32.0]
	294.62	—[438.4]	1.42	—[36.0]
	320.84	—[477.4]	1.57	—[40.0]
20 by 20 [510 by 510]	130.85	—[194.7]	0.50	—[12.7]
	163.12	—[242.7]	0.63	—[16.0]
	192.31	—[286.1]	0.75	—[19.1]
	206.66	—[307.49]	0.81	—[20.57]
	214.68	—[319.4]	0.87	—[22.0]
	240.67	—[358.1]	0.98	—[25.0]
	265.88	—[395.6]	1.10	—[28.0]
	298.26	—[443.8]	1.26	—[32.0]
	329.25	—[489.9]	1.42	—[36.0]
	358.83	—[533.9]	1.57	—[40.0]
	393.84	—[586.0]	1.77	—[45.0]
	426.66	—[634.8]	1.97	—[50.0]
22 by 22 [560 by 560]	177.48	—[264.1]	0.63	—[16.0]
	208.27	—[309.9]	0.75	—[19.0]
	238.27	—[354.5]	0.87	—[22.0]
	267.48	—[398.0]	0.98	—[25.0]
	295.90	—[440.3]	1.10	—[28.0]
	332.57	—[494.8]	1.26	—[32.0]
	367.84	—[547.3]	1.42	—[36.0]
	401.71	—[597.7]	1.57	—[40.0]
	442.08	—[657.8]	1.77	—[45.0]
	480.27	—[714.6]	1.97	—[50.0]
	516.26	—[768.1]	2.17	—[55.0]
24 by 24 [610 by 610]	194.64	—[289.6]	0.63	—[16.0]
	228.64	—[340.2]	0.75	—[19.0]
	261.85	—[389.6]	0.87	—[22.0]
	294.28	—[437.9]	0.98	—[25.0]
	325.92	—[484.9]	1.10	—[28.0]
	366.87	—[545.9]	1.26	—[32.0]
	406.43	—[604.7]	1.42	—[36.0]
	444.59	—[661.5]	1.57	—[40.0]
	490.32	—[729.6]	1.77	—[45.0]
	533.87	—[794.3]	1.97	—[50.0]
	575.22	—[855.9]	2.17	—[55.0]



TABLE 3—Continued

Size Given in Outside Dimensions Across Flat Sides, in. [mm]	Weight per Unit Length, lb/ft [kg/m]	Calculated Nominal Wall Thickness, in. [mm]		
	614.39	{914.2}	2.36	{60.0}
26 by 26 [660 by 660]	211.79	{315.1}	0.63	{16.0}
	249.01	{370.5}	0.75	{19.0}
	285.44	{424.7}	0.87	{22.0}
	321.08	{477.7}	0.98	{25.0}
	355.93	{529.6}	1.10	{28.0}
	401.18	{596.9}	1.26	{32.0}
	445.03	{662.2}	1.42	{36.0}
	487.48	{725.3}	1.57	{40.0}
	538.57	{801.3}	1.77	{45.0}
	587.47	{874.1}	1.97	{50.0}
	634.19	{943.6}	2.17	{55.0}
678.72	{1009.9}	2.36	{60.0}	
28 by 28 [710 by 710]	228.94	{340.6}	0.63	{16.0}
	269.38	{400.8}	0.75	{19.0}
	309.02	{459.8}	0.87	{22.0}
	347.88	{517.6}	0.98	{25.0}
	385.95	{574.3}	1.10	{28.0}
	435.49	{648.0}	1.26	{32.0}
	483.62	{719.6}	1.42	{36.0}
	530.36	{789.1}	1.57	{40.0}
	586.81	{873.1}	1.77	{45.0}
	641.07	{953.9}	1.97	{50.0}
	693.15	{1031.3}	2.17	{55.0}
743.04	{1105.6}	2.36	{60.0}	
30 by 30 [760 by 760]	246.10	{366.2}	0.63	{16.0}
	289.75	{431.1}	0.75	{19.0}
	332.61	{494.9}	0.87	{22.0}
	374.68	{557.5}	0.98	{25.0}
	415.97	{618.9}	1.10	{28.0}
	469.79	{699.0}	1.26	{32.0}
	522.22	{777.0}	1.42	{36.0}
	573.24	{852.9}	1.57	{40.0}
	635.05	{944.9}	1.77	{45.0}
	694.68	{1033.6}	1.97	{50.0}
	752.12	{1119.1}	2.17	{55.0}
807.36	{1201.3}	2.36	{60.0}	

TABLE 4 Dimensions of Common Sizes of Rectangular Structural Tubing

Size Given in Outside Dimensions Across Flat Sides, in. [mm]	Weight per Unit Length, lb/ft [kg/m]	Calculated Nominal Wall Thickness, in. [mm]
3 by 2 [75 by 50]	4.32 [6.4]	0.141 [3.58]
	5.50 [8.3]	0.188 [4.78]
	7.10 [10.6]	0.250 [6.35]
4 by 2 [100 by 50]	5.78 [8.6]	0.156 [3.96]
	6.86 [10.2]	0.188 [4.78]
	8.80 [13.1]	0.250 [6.35]
4 by 3 [100 by 75]	6.88 [10.2]	0.156 [3.96]
	8.14 [12.1]	0.188 [4.78]
	10.50 [15.6]	0.250 [6.35]
	12.69 [18.9]	0.312 [7.92]
5 by 3 [130 by 75]	9.31 [13.9]	0.188 [4.78]
	12.02 [17.9]	0.250 [6.35]
	14.52 [21.6]	0.312 [7.92]
	16.84 [25.1]	0.375 [9.52]
6 by 3 [150 by 75]	10.58 [15.7]	0.188 [4.78]
	13.72 [20.4]	0.250 [6.35]
	16.65 [24.8]	0.312 [7.92]
	19.39 [28.9]	0.375 [9.52]
6 by 4 [150 by 100]	11.86 [17.7]	0.188 [4.78]
	15.42 [22.9]	0.250 [6.35]
	18.77 [27.9]	0.312 [7.92]
	21.94 [32.7]	0.375 [9.52]